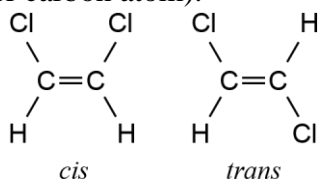


## ANSWERS: Isomers

1. (i) A constitutional (structural) isomer has the same molecular formula, but a different arrangement of atoms / different structural formula.

(ii) 1,1-dichloroethene cannot exist as a geometric isomer because, although there is a double bond, the atoms / groups on each of the carbon atoms of the double bond are the same (2 Cl on one C and 2 H on the other carbon atom).



(iii) 1,2 dichloroethene

2.



For *cis* and *trans* isomers to occur a carbon-carbon double bond must be present as this prevents any rotation about this bond, and the atoms or groups of atoms attached to the two carbon atoms are therefore fixed in position. This means that molecule **C** cannot have *cis* and *trans* isomers as it does not have a double bond. For compound **B** one of the carbon atoms in the double bond has two of the same atom attached to it (two H's). Therefore it cannot have *cis* and *trans* isomers because if these two H atoms swapped position it would still be the same molecule. Therefore only compound **A** can have *cis* and *trans* isomers as it does have a double bond preventing free rotation, and it does not have one of the carbons in the double bond with two of the same atom or groups of atoms attached to it.

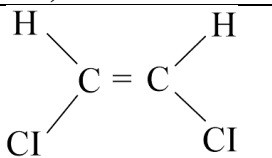
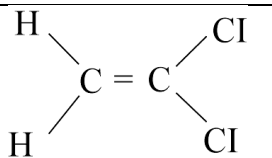
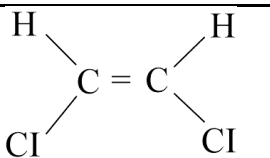
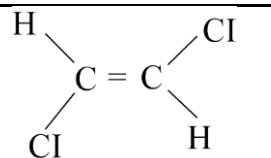
3. A and F

Constitutional / structural isomers have the same molecular formula (they have the same type and number of atoms) but different constitutional / structural formulae (atoms are arranged differently). These molecules both have the same number and type of atoms but the atoms are arranged differently;  $\text{C}_4\text{H}_9\text{Cl}$  / the chlorine is on a different carbon atom. *Cis-trans* isomers can occur in molecules that have (carbon to carbon) double bond because atoms are not free to rotate around (the axis of) the double bond. They must also have two different groups attached to each carbon (involved in the double bond). Molecule D has a carbon-carbon double bond. One carbon of the double bond is attached to a hydrogen atom and an ethyl group. The other is attached to a hydrogen atom and a chlorine atom.

$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & & \\  &   &   &   &   & & \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{OH} \\  &   &   &   &   & & \\  & \text{H} & \text{H} & \text{H} & \text{H} & &   \end{array}  $ <p>butan-1-ol</p>	$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{OH} & \text{H} & & \\  &   &   &   &   & & \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\  &   &   &   &   & & \\  & \text{H} & \text{H} & \text{H} & \text{H} & &   \end{array}  $ <p>or</p> $  \begin{array}{c}  \text{CH}_3\text{CH}_2\text{CHCH}_3 \\    \\  \text{OH} \\  \text{butan-2-ol}  \end{array}  $	$  \begin{array}{ccccccc}  & & \text{CH}_3 & & \text{H} & & \\  & &   & &   & & \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{OH} \\  &   &   &   & & & \\  & \text{H} & \text{H} & \text{H} & & &   \end{array}  $ <p>or</p> $  \begin{array}{c}  \text{CH}_3\text{CHCH}_2\text{OH} \\    \\  \text{CH}_3 \\  \text{methylpropan-1-ol}  \end{array}  $	$  \begin{array}{ccccccc}  & & \text{CH}_3 & & \text{H} & & \\  & &   & &   & & \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{H} \\  &   &   &   & & & \\  & \text{H} & \text{OH} & \text{H} & & &   \end{array}  $ <p>or</p> $  \begin{array}{c}  \text{CH}_3 \\    \\  \text{CH}_3\text{CCH}_3 \\    \\  \text{OH} \\  \text{methylpropan-2-ol}  \end{array}  $
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5. No; for a molecule to exist as geometric isomers, it must contain a double bond, and each carbon (involved in the double bond) must have two different atoms / groups attached to it. But-1-ene has a double bond, but the atoms attached to one carbon are both the same (two hydrogen atoms) so it does not form a geometric isomer.

6. a)

 <p>1, 2-dichloroethene</p>	 <p>1, 1-dichloroethene</p>	 <p><b>cis</b> 1, 2-dichloroethene</p>	 <p><b>trans</b> 1, 2-dichloroethene</p>
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c) Structural isomers are compounds with the same molecular formula (they have the same type and number of atoms) but different structural formulae (structures).

$C_2H_4Cl_2$  has two structural isomers, one has a condensed structural formula  $CH_2Cl-CH_2Cl$  and the other  $CH_3-CHCl_2$

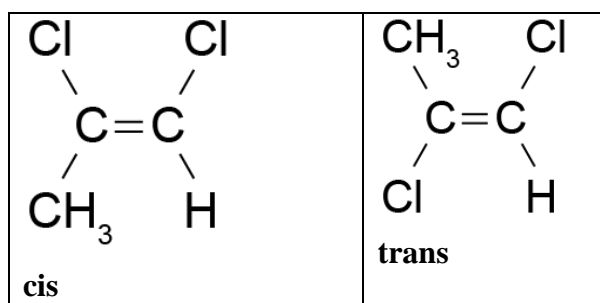
$C_2H_2Cl_2$  also has structural isomers, one has a condensed structural formula  $CH_2Cl-CHCl$  and the other  $CH_2=CCl_2$

Geometric isomers are compounds with the same molecular formula, the same (condensed) structural formula but different arrangement of atoms. It occurs in molecules that have double bonds because the rotation of the atoms about the axis of the carbon to carbon double bond is restricted. They must also have two different groups attached to each end of the double bond.

$C_2H_4Cl_2$  doesn't have a double bond; it has a single bond between the carbon atoms. Rotation of the atoms about this bond can occur freely so  $C_2H_4Cl_2$  cannot form geometric isomers.

$C_2H_2Cl_2$  has a double bond and each carbon involved has two different groups attached to them so  $C_2H_2Cl_2$  can form geometric isomers.

7.



Geometric isomers occur in molecules that have a carbon to carbon double bond which restricts the rotation of atoms about the axis of this double bond and two different groups attached to each of the carbons involved in the double bond.

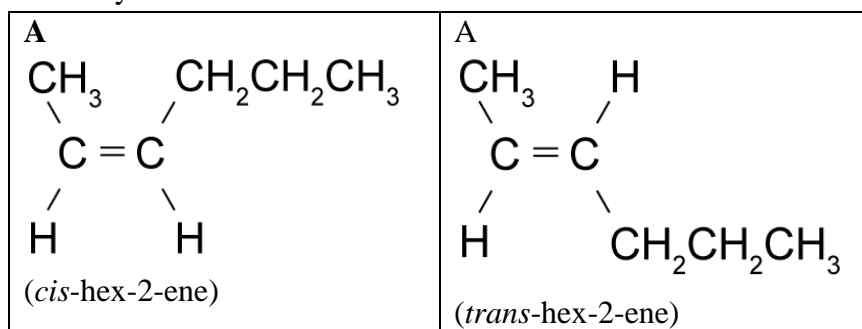
Molecule C can exist as *cis-trans* isomers, because this molecule has a carbon to carbon double bond, and it also has a chlorine atom and a hydrogen atom (two different groups) attached to each of the carbons involved in the double bond.

Molecule A cannot be a geometric isomer, as it does not have a carbon to carbon double bond.

Molecule B cannot be a geometric isomer, because although it has a carbon to carbon double bond, the two atoms attached to these carbons are both the same / hydrogen atoms.

## 8. C and D

They have the same molecular formula  $C_7H_{14}$ , the same number of carbon and hydrogen atoms, but their atoms are arranged differently.

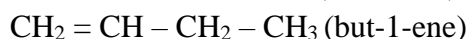
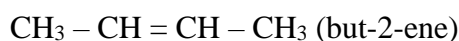


*Cis-trans* isomers occur in molecules that have carbon-to-carbon double bonds because rotation of the atoms about the axis of the carbon-to-carbon double bond is restricted.

They must also have two different groups attached to each of the carbons involved in the double bond.

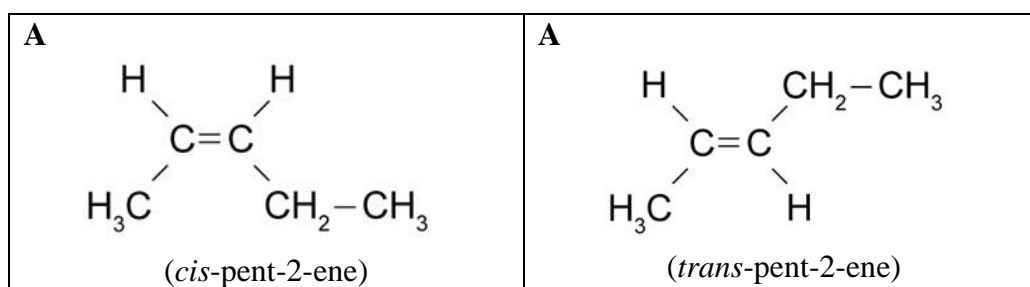
Molecule A, hex-2-ene, has a double bond. It has two different groups attached to the carbons, i.e. one carbon of the double bond is attached to H and  $CH_3$  and the other carbon is attached to H and  $CH_2CH_2CH_3$ .

## 9. Structural isomers are:



**10. a)** Structural isomers have the same molecular formula but they differ in the sequence in which the atoms are joined together.

**b)**



**c)** *Cis-trans* isomers can occur in molecules that have double bonds, because rotation of the atoms about the axis of the carbon to carbon double bond is restricted.

They must also have two different groups attached to each of the carbons involved in the double bond.

Molecule **A** (pent-2-ene) has a double bond, and each carbon involved in the double bond has two different groups attached to them.

Molecule **C** has no double bonds, so cannot exist as *cis-trans* isomers.

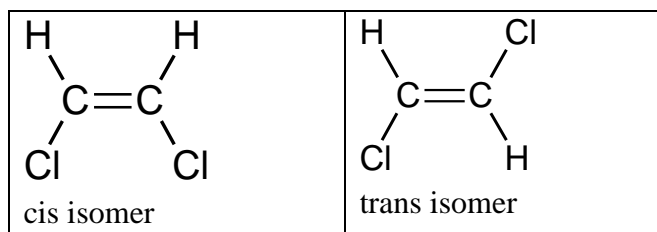
Molecule **B** and Molecule **D** have double bonds. However each carbon involved in the double bond does not have 2 different groups attached.

## 11. E, G and H

Structural isomers have the same number of atoms of each element / E, G and H all contain 4 C's, 10 H's and 1 O atom / same molecular formula and they have a different structure / atoms are joined differently / bonded together in a different order .

12 a) 1,2-dichloroethene circled.

b)



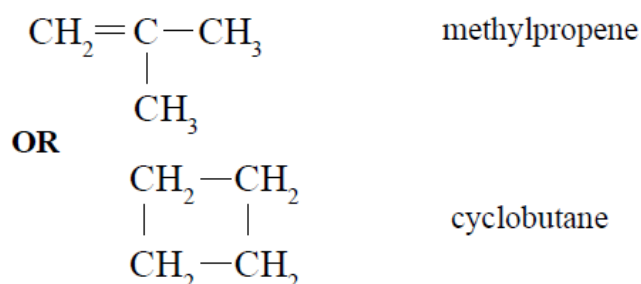
c) *Cis-trans* (geometric) isomers exist where there is a C=C which cannot freely rotate.

If there are two different groups bonded to the Cs of the double bond, two arrangements are possible.

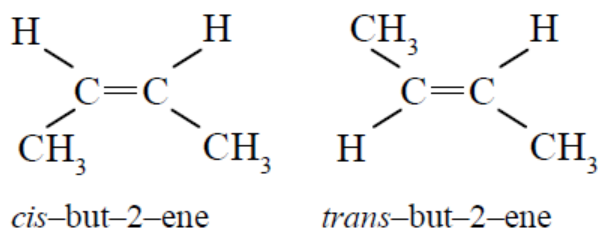
1,2-dichloroethene meets these requirements since each C of the double bond has -H and -Cl, ie different groups.

However, 1,1-dichloroethene does not meet these requirements since the two groups on the Cs of the double bond are the same, ie one C has two -H and the other two -Cl.

13.



*Cis-trans* isomers occur in molecules where a C=C doublebond prevents rotation around the C atoms. Also each carbon at the double bond has two different groups or atoms attached to it so that two different arrangements are possible. But-2-ene can have *cis* and *trans* forms as shown:



But-1-ene cannot exist as *cis-trans* forms since the groups or atoms attached to the carbon atoms forming the double bond are not different.

